COMPOSTING PROCESS BY USING PALM OIL MILL EFFLUENT (POME) AEROBIC SLUDGE, DECANTER CAKE AND RICE HUSK ASH

NUR EZYAN BINTI BADRUL HISHAM

MASTER OF SCIENCE

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis, and, in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.

DR. NOR HANUNI BT RAMLI@SAID
Senior Lecturer
Faculty of Chemical & Natural Resources Engineering
Universiti Malaysia Pahang
Lebuhraya Tun Razak, 26300 Gambang
Kuantan, Pahang
Tel : +609-549 2910 Fax : +609-549 2889

(Supervisor's Signature)

Full Name : Dr. Nor Hanuni Binti Ramli@Said

Position : Senior Lecturer

Date : 30/6/2020

DR. FATMAWATI BINTI ADAM
Associate Professor
Faculty of Chemical & Natural Resources Engineering
Universiti Malaysia Pahang
Lebuhraya Tun Razak, 26300 Gambang, Pahang

(Co-supervisor's Signature)

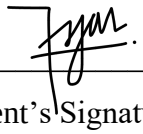
Full Name : Asc. Prof. Dr. Fatmawati Binti Adam

Position : Senior Lecturer

Date : 30/6/2020

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.



(Student's Signature)

Full Name : NUR EZYAN BINTI BADRUL HISHAM

ID Number : MKC16021

Date : 30/6/2020

COMPOSTING PROCESS BY USING PALM OIL MILL EFFLUENT (POME) AEROBIC SLUDGE, DECANTER CAKE AND RICE HUSK ASH

NUR EZYAN BINTI BADRUL HISHAM

Thesis submitted in fulfillment of the requirements
for the award of the degree of
Master of Science

Faculty of Chemical & Process Engineering Technology

UNIVERSITI MALAYSIA PAHANG

JULY 2020

ACKNOWLEDGEMENTS

I would like to thank the following people and organisations;

1. My supervisor, Dr.Nor Hanuni Binti Ramli@Said for her endless encouragement, motivation, guidance and critics.
2. My sister, Nur Eliza Binti Badrul Hisham for her endless assistance for me to finish my thesis.
3. LKPP Corporation Sdn. Bhd., Kuantan, Pahang, Malaysia for providing the raw materials for this research without any charge.
4. Person-in-charge at Environmental Engineering laboratory University Malaysia Pahang for their cooperation and guidance in using equipment at the laboratory.

ABSTRAK

Industri kilang kelapa sawit telah menyumbang kepada pencemaran yang signifikan terutamanya pencemaran sungai apabila mereka melepaskan efluen mereka seperti kumbahan POME dan kek dekanter ke dalam sungai. Untuk menyelesaikan masalah alam sekitar, sisa-sisa ini boleh digunakan sebagai baja melalui proses pengkomposan. Walau bagaimanapun, terdapat beberapa kelemahan yang mungkin berlaku dalam proses pengkomposan dari segi masa yang diperlukan dan kualiti kompos. Untuk memudahkan proses pengkomposan, adalah disarankan untuk menggunakan abu sekam padi sebagai bahan mentah tambahan kerana sifat fizikal dan kimianya. Objektif kerja ini adalah untuk mencirikan sifat fizikal dan kimia bahan mentah (enapcemar POME aerobik, kek dekanter, abu sekam padi), untuk memformulasikan baja kompos organic pada komposisi abu sekam padi yang berbeza, untuk menilai kesan pemanasan terhadap proses pengkomposan dan untuk membandingkan sifat fizikokimia kompos yang dirumuskan dengan produk komersial yang sedia ada. Dalam kerja ini, enapcemar POME aerobik dan kek dekanter dicampurkan dengan nisbah berat tetap (1:1) dengan penambahan jumlah abu sekam padi yang berbeza. Kemudian, proses pengkomposan dilakukan selama 50 hari dengan menggunakan tong kompos. Semasa proses pengkomposan, profil suhu dan pH kompos dipantau setiap hari. Setelah proses pengkomposan selesai, kompos yang matang dianalisis dari segi analisis unsur, pH, kandungan kelembapan dan kapasiti pegangan air. Keputusan menunjukkan bahawa komposisi abu sekam padi sebanyak 6.98% menunjukkan hasil yang signifikan dalam rumusan kompos kerana berjaya mengekalka kandungan kelembapan pada julat 50-60% dan julat 61-73% untuk kapasiti pegangan air. Pada akhir pengkomposan, sampel yang mengandungi 6.98% abu sekam padi memperoleh pH 6.44, nisbah C/N sebanyak 10.28 dan nisbah N-P-K sebanyak 3.3-8.1-9.7. Hasil daripada kajian ini digunakan untuk kajian yang seterusnya dengan menggunakan kaedah pemanasan paksa. Kaedah pemanasan paksa menghasilkan kompos yang mengandungi kelembapan dan kapasiti pegangan air yang rendah berbanding kaedah tong kompos. Walau bagaimanapun, kedua-dua kaedah tidak memberikan perbezaan ketara dari segi sifat kimia (makronutrien dan mikronutrien).

ABSTRACT

Palm oil mill industry had contributed to significant pollution especially river pollution when they discharged their effluents such as POME sludge and decanter cake into the rivers. To solve the environmental problem, these wastes can be utilized as fertilizer through composting process. However, there are some drawbacks in which possibly occur in composting process such as time consuming and the quality of compost. In order to facilitate the composting process, it was suggested to use rice husk ashes as additional raw materials due to its physical and chemical properties. The objectives of this work are to characterize the physical and chemical properties of raw materials (POME aerobic sludge, decanter cake, rice husk ash), to formulate the organic compost at different rice husk ash composition, to observe the heating effect towards the composting process and to compare the physicochemical properties of formulated compost with existing commercial product. In this work, POME aerobic sludge and decanter cake were mixed at constant weight ratio of (1:1) with addition of different amount of rice husk ashes. Then, the composting processes were carried out in 50 days by using compost bins. During the composting process, temperature and pH profile of compost were monitored daily. After composting process completed, the matured compost was analysed in terms of elemental analysis, pH, moisture content and water holding capacity. The result indicates that rice husk ash composition at 6.98% gives significant results in the compost formulation as the moisture content maintain within the range of 50-60% and range of 61-73% for water holding capacity. At the end of composting, sample with 6.98% rice husk ash obtain pH of 6.44, C/N ratio of 10.28 and N-P-K ratio of 3.3-8.1-9.7. The results obtain from this study were used for subsequent study by using forced heating composter. Forced heating composter produced compost with lower moisture content and water holding capacity compared to compost bin. However, composting by using both methods did not give significant difference in terms of chemical properties (macronutrients and micronutrients).

Key words: POME aerobic sludge, decanter cake, rice husk ash, composting

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

cm	Centimeters
g	Grams
ºC	Degree celcius

LIST OF ABBREVIATIONS

BOD	Biological Oxygen Demand
C	Carbon
CHNS	Carbon Hydrogen Nitrogen Sulphur
COD	Chemical Oxygen Demand
EFB	Empty fruit bunch
FFB	Fresh fruit bunch
K	Potassium
MC	Moisture content
N	Nitrogen
P	Phosphorus
PKC	Palm kernel cake
POME	Palm oil mill effluent
POMS	Palm oil mill sludge
RHA	Rice husk ash
Si	Silica
SSF	Solid-State Fermentation
TSS	Total Suspended Solid
VSS	Volatile Suspended Solid
WHC	Water holding capacity
XRF	X-Ray Fluorescence

REFERENCES

Abbas, S., Kazmi, S. M. S., & Munir, M. J. (2017). Potential of rice husk ash for mitigating the alkali-silica reaction in mortar bars incorporating reactive aggregates. *Construction and Building Materials*, *132*, 61–70. doi:10.1016/j.conbuildmat.2016.11.126

Abdul Razak, M. N., Ibrahim, M. F., Yee, P. L., Hassan, M. A., & Abd-Aziz, S. (2012). Utilization of oil palm decanter cake for cellulase and polyoses production. *Biotechnology and Bioprocess Engineering*, *17*, 547–555. doi:10.1007/s12257-011-0590-9

Adam, M. A., Sulaiman, A., Said, C. M. S., Som, A. M., Bahruddin, A. S., & Mokhtar, M. N. (2014). Preliminary Study of Oil Palm Decanter Cake Natural Polymer Composite (OPDC-NPC). *Advanced Materials Research*, *911*, 40–44. doi:10.4028/www.scientific.net/AMR.911.40

Agostinho, F., Tubana, B., Martins, M., & Datnoff, L. (2017). Effect of Different Silicon Sources on Yield and Silicon Uptake of Rice Grown under Varying Phosphorus Rates. *Plants*, *6*(3), 35. doi:10.3390/plants6030035

Ahmad, M. N., Mokhtar, M. N., Baharuddin, A. S., Lim, S. H., Ahmad Ali, S. R., Abd-Aziz, S., … Hassan, M. A. (2011). Co-composting of oil palm frond. *BioResources*, *6*(4), 4762–4780.

Ajmera, I., Charlie Hodgman, T., & Lu, C. (2019). An integrative systems perspective on plant phosphate research. *Genes*, *10*(2). doi:10.3390/genes10020139

Akhbari, A., Kutty, P. K., Chuen, O. C., & Ibrahim, S. (2019). A study of palm oil mill processing and environmental assessment of palm oil mill effluent treatment. *Environmental Engineering Research*, *25*(2), 212–221. https://doi.org/10.4491/eer.2018.452

Al-bataina, B. B., Young, T. M., & Ranieri, E. (2016). International Soil and Water Conservation Research Effects of compost age on the release of nutrients. *International Soil and Water Conservation Research*, *4*(3), 230–236. doi:10.1016/j.iswcr.2016.07.003

Alavi, N., Daneshpajou, M., Shirmardi, M., Goudarzi, G., Neisi, A., & Babaei, A. A. (2017). Investigating the efficiency of co-composting and vermicomposting of vinasse with the mixture of cow manure wastes, bagasse, and natural zeolite. *Waste Management*, *69*, 117–126. doi:10.1016/j.wasman.2017.07.039

Alkarimiah, R., & Suja', F. (2020). Composting of EFB and POME Using a Step-feeding Strategy in a Rotary Drum Reactor: The Effect of Active Aeration and Mixing Ratio on Composting Performance. *Polish Journal of Environmental Studies*, *29*(4), 2543–2553. doi:10.15244/pjoes/110518

Alkoaik, F., Al-faraj, A., Al-helal, I., Fulleros, R., Ibrahim, M., & Abdel-ghany, A. M. (2020). Toward Sustainability in Rural Areas : Composting Palm Tree Residues in Rotating Bioreactors. *Sustainability*, *12*(201), 1–11.

Alkoaik, F. N. (2019). Integrating aeration and rotation processes to accelerate composting of agricultural residues. *PLoS ONE*, *14*(7), 1–14. doi:10.1371/journal.pone.0220343 J

Alkoaik, F. N., Abdel-ghany, A. M., Al-helal, I. M., Rashwan, M. A., Fulleros, R. B., & Ibrahim, M. N. (2019). Effect of Insulation on the Performance of a Rotary Bioreactor for Composting Agricultural Residues. *Energies*, *12*(315), 1–13. doi:10.3390/en12020315

Almaz, M. G., Halim, R. A., Martini, M. Y., & Samsuri, A. W. (2017). Integrated Application of Poultry Manure and Chemical Fertiliser on Soil Chemical Properties and Nutrient Uptake of Maize and Soybean. *Malaysian Journal of Soil Science*, *21*, 13–28.

Angima, S., Noack, M., & Noack, S. (2011). Composting with worms. *Oregon State University*, 1–13. Retrieved from http://ir.library.oregonstate.edu

Arifin, B., Bono, A., & Janaun, J. (2006). The Transformation of Chicken Manure Into Mineralized Organic Fertilizer. *Journal of Sustainability Science and Management*, *1*(1), 58–63.

ASTM D1293-18. (2018). Standard Test Methods for pH of Water. *ASTM International*. West Conshohocken, Pennsylvania. doi:10.1520/D1293-18

ASTM D2980-02. (2002). Standard Test Method for Volume Weights, Water-Holding Capacity, and Air Capacity of Water-Saturated Peat Materials. *ASTM International*. West Conshohocken, Pennsylvania. doi:10.1520/D2980-02

ASTM D4442-16. (2016). Standard Test Methods for Direct Moisture Content Measurement of Wood and Wood-Based Materials. *ASTM International*. West Conshohocken, Pennsylvania. doi:10.1520/D4442-16

ASTM D5373-08. (2008). Standard Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Laboratory Samples of Coal. *ASTM International*. West Conshohocken, Pennsylvania. doi:10.1520/D5373-08

Baharuddin, A. S., Hock, L. S., Yusof, M. Z., Abdul, N. A., Shah, U., Hassan, M. A., … Shirai, Y. (2010). The effect of Palm Oil Mill Effluent (POME) anaerobic sludge from 500 m^3 of closed anaerobic methane digested tank on pressed-shredded Empty Fruit Bunch (EFB) composting process. *African Journal of Biotechnology*, *9*(16), 2427–2436. doi:10.5897/AJB10.1418

Bakar, A. A., Mahmood, N. Z., Abdullah, N., & Taha, R. M. (2012). Bioconversion of biomass residue from the cultivation of pea sprouts on spent Pleurotus sajor-caju compost employing Lumbricus rubellus. *Maejo International Journal of Science and Technology*, *6*(3), 461–469.

Bakar, R. A., Yahya, R., & Gan, S. N. (2016). Production of High Purity Amorphous Silica from Rice Husk. *Procedia Chemistry*, *19*(March), 189–195. doi:10.1016/j.proche.2016.03.092

Bean, M. (2020). A Crash Course in Fertilizers: NPK Ratios, Synthetic vs. Organic, and More. Retrieved May 18, 2020, from https://www.sunset.com/garden/garden-basics/crash-course-fertilizers

Benassi, L., Franchi, F., Catina, D., Cioffi, F., Rodella, N., Borgese, L., … Bontempi, E. (2015). Rice Husk Ash to Stabilize Heavy Metals Contained in Municipal Solid Waste Incineration Fly Ash : First Results by Applying New Pre-treatment Technology, 6868–6879. doi:10.3390/ma8105346

Cáceres, R., Malin´ska, K., & Marfà, O. (2018). Nitrification within composting : A review. *Waste Management*, *72*, 119–137. doi:10.1016/j.wasman.2017.10.049

Carneiro, L. J., Costa, M. S. S. de M., Costa, L. A. de M., Martins, M. F. L., & Rozatti, M. A. T. (2013). Nutrient loss in composting of agroindustrial residues. *Engenharia Agrícola*, *33*(4), 796–807. doi:10.1590/S0100-69162013000400019

Chadha, A., Florentine, S. K., Chauhan, B. S., Long, B., & Jayasundera, M. (2019). Influence of soil moisture regimes on growth, photosynthetic capacity, leaf biochemistry and reproductive capabilities of the invasive agronomic weed; Lactuca serriola. *PLoS ONE*, *14*(6), 1–17. doi:10.1371/journal.pone.0218191

Chandna, P., Nain, L., Singh, S., & Kuhad, R. (2014). Correction: assessment of bacterial diversity during composting of agricultural byproducts. *BMC Microbiology*, *14*(1), 33. doi:10.1186/1471-2180-14-33

Chen, L., Yang, X., Raza, W., Luo, J., Zhang, F., & Shen, Q. (2011). Solid-state fermentation of agro-industrial wastes to produce bioorganic fertilizer for the biocontrol of Fusarium wilt of cucumber in continuously cropped soil. *Bioresource Technology*, *102*(4), 3900–3910. doi:10.1016/j.biortech.2010.11.126

Chen, Z., Wang, H., Ionita, C., Luo, F., & Jiang, X. (2015). Thermal Resistance of Desiccation-Adapted Salmonella spp . *Applied and Environmental Microbiology*, *81*(19), 6883–6889. doi:10.1128/AEM.01876-15

Cherypiew, N., & Suksaroj, T. T. (2014). Waste Management in the Palm Oil Industry : a Case Study of Co-Composting of Oil Palm Empty Fruit. In *Proceedings of Fifth TheIIER-SCIENCE PLUS International Conference* (pp. 31–35). Singapore.

Corral, M. A. M., Wong, J. A. C., Martínez, J. M., & Cuevas, L. R. (2019). Effect of different initial C / N ratio of cow manure and straw on microbial quality of compost. *International Journal of Recycling of Organic Waste in Agriculture*, *8*(s1), 357–365. doi:10.1007/s40093-019-00308-5

Dede, O. H., & Ozer, H. (2018). Enrichment of poultry manure with biomass ash to produce organomineral fertiliser. *Environmental Engineering Research*, *23*(4), 449–455.

Dewayanto, N., Isha, R., & Ridzuan, M. (2014). Use of palm oil decanter cake as a new substrate for the production of bio-oil by vacuum pyrolysis. *Energy Conversion and Management*, *86*, 226–232. doi:10.1016/j.enconman.2014.04.078

Ding, Y., Liu, Y., Liu, S., Li, Z., & Tan, X. (2016). Biochar to improve soil fertility . A review. *Agronomy for Sustainable Development*. doi:10.1007/s13593-016-0372-z

Elzer-Peters, K. (2013). *SOUTHERN FRUIT & VEGETABLE GARDENING*. (M. Johanson, Ed.) (1st ed.). Minneapolis, Minnesota: Cool Springs Press.

Emamverdian, A., Ding, Y., Xie, Y., & Sangari, S. (2018). Silicon Mechanisms to Ameliorate Heavy Metal Stress in Plants. *BioMed Research International*, *2018*, 1–10.

Embrandiri, A., Fatemeh, P., Sultan, R., & Ismail, A. (2016). The effect of oil palm decanter cake on the accumulation of nutrients and the stomatal opening of Solanum melongena (brinjal) plants. *International Journal of Recycling of Organic Waste in Agriculture*, *5*(2), 141–147. doi:10.1007/s40093-016-0124-8

Embrandiri, A., Rupani, P. F., Ismail, S. A., Singh, R. P., Ibrahim, M. H., & b. Abd. Kadir, M. O. (2016). The effect of oil palm decanter cake on the accumulation of nutrients and the stomatal opening of Solanum melongena (brinjal) plants. *International Journal of Recycling of Organic Waste in Agriculture*, *5*(2), 141–147. doi:10.1007/s40093-016-0124-8

Erana, F. G., Asfaw, S. L., & Tenkegna, T. A. (2019). Composting of Digestate from Anaerobic Tannery Wastes Biogas for Plant Nutrition. *EC Agriculture*, *3*, 147–161.

Evans, G. (2014). *Biowaste and biological waste treatment*. London: James & James (Science Publishers) Ltd. Retrieved from https://books.google.com.my/books?id=pCJpAwAAQBAJ&dq=cn+ratio+in+maturation+phase&source=gbs_navlinks_s

Febrisiantosa, A., Ravindran, B., & Choi, H. L. (2018). The Effect of Co-Additives (Biochar and FGD Gypsum) on Ammonia Volatilization during the Composting of Livestock Waste. *Sustainability*, *10*, 1–18. doi:10.3390/su10030795

Fulekar, M. (2010). *Environmental Biotechnology*. (A. K. Peters, Ed.) (1st ed.). New York: CRC Press.

Gao, M., Li, B., Yu, A., Liang, F., Yang, L., & Sun, Y. (2010). The effect of aeration rate on forced-aeration composting of chicken manure and sawdust. *Bioresource Technology*, *101*(6), 1899–1903. doi:10.1016/j.biortech.2009.10.027

Gao, M., Liang, F., Yu, A., Li, B., & Yang, L. (2010). Evaluation of stability and maturity during forced-aeration composting of chicken manure and sawdust at different C/N ratios. *Chemosphere*, *78*(5), 614–619. doi:10.1016/j.chemosphere.2009.10.056

Gentili, R., Ambrosini, R., Montagnani, C., Caronni, S., & Citterio, S. (2018). Effect of Soil pH on the Growth , Reproductive Investment and Pollen Allergenicity of Ambrosia. *Frontiers in Plant Science*, *9*(September), 1–12. doi:10.3389/fpls.2018.01335

Gould, C. (2015). Compost increases the water holding capacity of droughty soils. Retrieved from https://www.canr.msu.edu/news/compost_increases_the_water_holding_capacity_of_droughty_soils

Goulding, K. W. T. (2016). Soil acidification and the importance of liming agricultural soils with particular reference to the United Kingdom. *Soil Use and Management*, *32*(3), 390–399. doi:10.1111/sum.12270

Greger, M., Landberg, T., & Vaculik, M. (2018). Silicon Influences Soil Availability and Accumulation of Mineral Nutrients in Various Plant Species. *Plants*, *7*(41), 1–16. doi:10.3390/plants7020041

Griineklee, E. (1998). Comparing Open versus In-Vessel Composting. In *Asia-North-American Waste Management Conference* (pp. 68–90). Los Angeles, California. Retrieved from http://www.seas.columbia.edu/earth/wtert/sofos/nawtec/anacon98/anacon98-04.pdf

Guo, R., Li, G., Jiang, T., Schuchardt, F., Chen, T., Zhao, Y., & Shen, Y. (2012). Effect of aeration rate, C/N ratio and moisture content on the stability and maturity of compost. *Bioresource Technology*, *112*, 171–178. doi:10.1016/j.biortech.2012.02.099

Gupta, R. K., Singh, A., Singh, Y., Thind, H. S., Singh, B., & Singh, V. (2014). Effects of Rice Husk Ash and Bagasse Ash on Phosphorus Adsorption and Desorption in an Alkaline Soil under Wheat-Rice System. *Communications in Soil Science and Plant Analysis*, *45*(10), 1385–1398. doi:10.1080/00103624.2014.884109

Hamzah, A., Hapsari, R. I., & Priyadarshini, R. (2017). The influence of rice husk and tobacco waste biochars on soil quality. *Journal of Degraded and Mining Lands Management*, *5*(1), 1001–1007. doi:10.15243/jdmlm.2017.051.1001

Hanc, A., & Dreslova, M. (2016). Effect of composting and vermicomposting on properties of particle size fractions. *Bioresource Technology*, *217*, 186–189. doi:10.1016/j.biortech.2016.02.058

Hanč, A., Tlustoš, P., Száková, J., & Balík, J. (2008). The influence of organic fertilizers application on phosphorus and potassium bioavailability. *Plant Soil Environment*, *54*(6), 247–254.

Hanin, A. N., Parveez, G. K. A., Rasid, O. A., & Masani, M. Y. A. (2020). Biolistic-mediated oil palm transformation with alfalfa glucanase (AGLU1) and rice chitinase (RCH10) genes for increasing oil palm resistance towards Ganoderma boninense. *Industrial Crops and Products*, *144*(November 2019), 112008. doi:10.1016/j.indcrop.2019.112008

Hasanuzzaman, M., Bhuyan, M. H. M. B., Nahar, K., Hossain, M. S., Al Mahmud, J., Hossen, M. S., … Fujita, M. (2018). Potassium: A vital regulator of plant responses and tolerance to abiotic stresses. *Agronomy*, *8*(3). doi:10.3390/agronomy8030031

Hassan, M. U., Aamer, M., Chattha, M. U., Ullah, M. A., Sulaman, S., Nawaz, M., … Huang, G. (2017). The Role of Potassium in Plants under Drought Stress: Mini Review. *Journal of Basic and Applied Sciences*, *13*(0), 268–271.

Heuer, S., Gaxiola, R., Schilling, R., Herrera-Estrella, L., López-Arredondo, D., Wissuwa, M., … Rouached, H. (2017). Improving phosphorus use efficiency: a complex trait with emerging opportunities. *Plant Journal*, *90*(5), 868–885. doi:10.1111/tpj.13423

Hossain, S. K. S., Mathur, L., Roy, P. K., Hossain, S. K. S., Mathur, L., & Rice, P. K. R. (2018). Rice husk / rice husk ash as an alternative source of silica in ceramics : A review. *Journal of Asian Ceramic Societies*, *6*(4), 299–313. doi:10.1080/21870764.2018.1539210

Huang, K., & Xia, H. (2018). Role of earthworms' mucus in vermicomposting system: Biodegradation tests based on humification and microbial activity. *Science of the Total Environment*, *610–611*, 703–708. doi:10.1016/j.scitotenv.2017.08.104

Hue, N. V., & Fox, R. L. (2010). Predicting plant phosphorus requirements for hawaii soils using a combination of phosphorus sorption isotherms and chemical extraction methods. *Communications in Soil Science and Plant Analysis*, *41*(2), 133–143. doi:10.1080/00103620903426949

Insam, H., & de Bertoldi, M. (2007). Chapter 3 Microbiology of the composting process. *Waste Management Series*, *8*, 25–48. doi:10.1016/S1478-7482(07)80006-6

Insam, H., Franke-Whittle, I., & Goberna, M. (2010). *Microbes at work : from wastes to resources*. (H. Insam, I. Franke-Whittle, & M. Goberna, Eds.). New Delhi, India: Springer-Verlag Berlin Heidelberg. Retrieved from https://books.google.com.my/books?id=5lhHN3Pq2goC&dq=Cooling+Phase+(Second+Mesophilic+Phase).+When+the+activity+of+the+thermophilic+organisms+ceases+due+to+exhaustion+of+substrates&source=gbs_navlinks_s

Iwuagwu, J., & Ugwuanyi, J. (2014). Treatment and Valorization of Palm Oil Mill Effluent through Production of Food Grade Yeast Biomass. *Journal of Waste Management*, *2014*, 1–9. doi:10.1155/2014/439071

Jain, M. S., Daga, M., & Kalamdhad, A. S. (2019). Variation in the key indicators during composting of municipal solid organic wastes. *Sustainable Environment Research*, *1*(1), 1–8. doi:10.1186/s42834-019-0012-9

Jeer, M., Suman, K., Maheswari, T. U., Voleti, S. R., & Padmakumari, A. P. (2018). Field Crops Research Rice husk ash and imidazole application enhances silicon availability to rice plants and reduces yellow stem borer damage. *Field Crops Research*, *224*(August 2017), 60–66. doi:10.1016/j.fcr.2018.05.002

Kananam, W., Tachapattaworakul, T., & Suksaroj, C. (2011). Biochemical changes during oil palm (Elaeis guineensis) empty fruit bunches composting with decanter sludge and chicken manure. *ScienceAsia*, *37*, 17–23. doi:10.2306/scienceasia1513-1874.2011.37.017

Kanchanasuta, S., & Pisutpaisal, N. (2017). Improvement of glycerol waste utilization by co-feedstock with palm oil decanter cake on biohydrogen fermentation. *International Journal of Hydrogen Energy*, 1–7. doi:10.1016/j.ijhydene.2016.12.134

Karim, M. Z., Yokota, S., Rahman, M. M., Eizawa, J., Saito, Y., Azad, M. A. K., … Yoshizawa, N. (2007). Effects of the Sucrose Concentration and pH Level on Shoot Regeneration from Callus in Araria elata Seem. *Asian Journal of Plant Sciences*, *6*(4), 715–717.

Kenso, M. (2017). BAJA ORGANIK. Retrieved April 22, 2020, from https://kenso.com.my/bm/baja-organik/

Khadaroo, S. N. B. A., Poh, P. E., Gouwanda, D., & Grassia, P. (2019). Applicability of various pretreatment techniques to enhance the anaerobic digestion of Palm oil Mill effluent (POME): A review. *Journal of Environmental Chemical Engineering*, *7*(5), 103310. doi:10.1016/j.jece.2019.103310

Kim, E., Lee, D. H., Won, S., & Ahn, H. (2016). Evaluation of optimum moisture content for composting of beef manure and bedding material mixtures using oxygen uptake measurement. *Asian-Australasian Journal of Animal Sciences*, *29*(5), 753–758. doi:10.5713/ajas.15.0875

Koyama, M., Nagao, N., Syukri, F., Rahim, A. A., Kamarudin, M. S., Toda, T., … Nakasaki, K. (2018). Effect of temperature on thermophilic composting of aquaculture sludge: NH3 recovery, nitrogen mass balance, and microbial community dynamics. *Bioresource Technology*, *265*(June), 207–213. doi:10.1016/j.biortech.2018.05.109

Krishnan, Y., Bong, C. P. C., Azman, N. F., Zakaria, Z., Othman, N., Abdullah, N., … Hara, H. (2016). Co-composting of palm empty fruit bunch and palm oil mill effluent: Microbial diversity and potential mitigation of greenhouse gas emission. *Journal of Cleaner Production*, *146*, 94–100. doi:10.1016/j.jclepro.2016.08.118

Krishnan, Y., Phun, C., Bong, C., & Farhana, N. (2016). Co-composting of palm empty fruit bunch and palm oil mill ef fl uent : Microbial diversity and potential mitigation of greenhouse gas emission. *Journal of Cleaner Production*, 1–7. doi:10.1016/j.jclepro.2016.08.118

Kumari, S., Bhattacharya, S., & Das, A. (2012). Solid-State Fermentation and Characterization of Amylase from a Thermophilic Aspergillus niger Isolated from Municipal Compost Soil. *Journal of Chemical, Biological and Physical Sciences*, *2*(2), 836–846.

Leela, D., Nur, S. M., Yandri, E., & Ariati, R. (2018). Performance of Palm Oil Mill Effluent (POME) as Biodiesel Source Based on Different Ponds. *E3S Web of Conferences*, *67*, 1–9. doi:10.1051/e3sconf/20186702038

Li, C., Gao, S., Zhang, J., Zhao, L., & Wang, L. (2016). Moisture Effect on Soil Humus Characteristics in a Laboratory Incubation Experiment. *Soil and Water Research*, *11*(1), 37–43. doi:10.17221/21/2015-SWR

Liang, C., Das, K. C., & McClendon, R. W. (2003). The influence of temperature and moisture contents regimes on the aerobic microbial activity of a biosolids composting blend. *Bioresource Technology*, *86*(2), 131–137. doi:10.1016/S0960-8524(02)00153-0

Lim, J. X., & Vadivelu, V. M. (2019). Enhanced volatile fatty acid production in sequencing batch reactor : Microbial population and growth kinetics evaluation Enhanced Volatile Fatty Acid Production in Sequencing Batch Reactor : Microbial Population and Growth Kinetics Evaluation. *AIP Conference Proceedings 2124*, *020040*(July).

Lim, L. Y., Phun, C. C. B., Lee, C. T., Lim, J. S., & Sarmidi, M. R. (2017). Review on the Current Composting Practices and the Potential of Improvement using Two-Stage Composting. *Chemical Engineering Transactions*, *61*, 1051–1056.

Lim, S. F., & Matu, S. U. (2015). Utilization of agro-wastes to produce biofertilizer. *International Journal of Energy and Environmental Engineering*, *6*(1), 31–35. doi:10.1007/s40095-014-0147-8

Lim, S. L., Lee, L. H., & Wu, T. Y. (2016). Sustainability of using composting and vermicomposting technologies for organic solid waste biotransformation: Recent overview, greenhouse gases emissions and economic analysis. *Journal of Cleaner Production*, *111*, 262–278. doi:10.1016/j.jclepro.2015.08.083

Lim, S. L., & Wu, T. Y. (2016). Characterization of Matured Vermicompost Derived from Valorization of Palm Oil Mill Byproduct. *Journal of Agricultural and Food Chemistry*, *64*(8), 1761–1769. doi:10.1021/acs.jafc.6b00531

Liu, C., Sung, Y., Chen, B., & Lai, H. (2014). Effects of Nitrogen Fertilizers on the Growth and Nitrate Content of Lettuce (Lactuca sativa L .). *International Journal of Environmental Research and Public Health*, *11*, 4427–4440. doi:10.3390/ijerph110404427

Long, Y., Liu, W., Yang, Y., & Shen, D. (2017). Effect of C/N on Water State during Composting of Kitchen Waste and Vegetable Waste Mixture. *Journal of Chemistry*, *2017*, 9409145. doi:10.1155/2017/9409145

Luyckx, M., Hausman, J.-F., Lutts, S., & Guerriero, G. (2017). Silicon and Plants: Current Knowledge and Technological Perspectives. *Frontiers in Plant Science*, *8*, 1–8. doi:10.3389/fpls.2017.00411

Maheshwari, D. K. (2014). *Composting for Sustainable Agriculture*. (D. K. Maheshwari, Ed.) (3rd ed.). London: Springer International Publishing. doi:10.1007/978-3-319-08004-8

Malakahmad, A., Idrus, N. B., Abualqumboz, M. S., Yavari, S., & Kutty, S. R. M. (2017). In-vessel co-composting of yard waste and food waste: an approach for sustainable waste management in Cameron Highlands, Malaysia. *International Journal of Recycling of Organic Waste in Agriculture*, *6*(2), 149–157. doi:10.1007/s40093-017-0163-9

Malińska, K., Golańska, M., Caceres, R., Rorat, A., Weisser, P., & Ślęzak, E. (2017). Biochar amendment for integrated composting and vermicomposting of sewage sludge – The effect of biochar on the activity of Eisenia fetida and the obtained vermicompost. *Bioresource Technology*, *225*, 206–214. doi:10.1016/j.biortech.2016.11.049

Mamimin, C., Jehlee, A., & Saelor, S. (2016). Thermophilic hydrogen production from co-fermentation of palm oil mill effluent and decanter cake by Thermoanaerobacterium thermosaccharolyticum PSU-2. *International Journal of Hydrogen Energy*, *41*(46), 21692–21701. doi:10.1016/j.ijhydene.2016.07.152

Manan, M. A., & Webb, C. (2018). Estimation of growth in solid state fermentation : A review. *Malaysian Journal of Microbiology*, *14*(1), 61–69.

Maniam, G. P., Hindryawati, N., Nurfitri, I., Jose, R., Ab. Rahim, M. H., Dahalan, F. A., & M. Yusoff, M. (2013). Decanter cake as a feedstock for biodiesel production: A first report. *Energy Conversion and Management*, *76*, 527–532. doi:10.1016/j.enconman.2013.07.077

Matichenkov, V. V., & Bocharnikova, E. A. (2001). The relationship between silicon and soil physical and chemical properties. *Studies in Plant Sciences*, *8*, 209–219. doi:10.1016/S0928-3420(01)80017-3

Matthews, K. R., Sapers, G. M., & Gerba, C. P. (2014). *The produce contamination problem : causes and solutions*. Retrieved from https://www.sciencedirect.com/book/9780124046115/the-produce-contamination-problem

Mayumi, A., Alovisi, T., Eduardo, A., Neto, F., Serra, A. P., Alovisi, A. A., … Fernandes, J. S. (2016). Phosphorus and silicon fertilizer rates effects on dynamics of soil phosphorus fractions in oxisol under common bean cultivation. *African Journal of Agriculture Research*, *11*(30), 2697–2707. doi:10.5897/AJAR2016.11304

Mills-Ibibofori, T., Dunn, B., Maness, N., & Payton, M. (2019). Use of diatomaceous earth as a silica supplement on potted ornamentals. *Horticulturae*, *5*(1), 1–12. doi:10.3390/horticulturae5010021

Misra, R. V., Roy, R. N., & Hiraoka, H. (2003). *On-farm composting methods*. (R. V. Misra, Ed.) (1st ed.). Rome: Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/3/a-y5104e.pdf

Moayedi, H., Aghel, B., Abdullahi, M., Nguyen, H., Safuan, A., & Rashid, A. (2019). Applications of rice husk ash as green and sustainable biomass. *Journal of Cleaner Production*, *237*, 117851. doi:10.1016/j.jclepro.2019.117851

Mohammad, N., & Kabashi, N. A. (2015). Optimization of effective composting process of oil palm industrial waste by lignocellulolytic fungi. *Journal of Material Cycles and Waste Management*, *17*(1), 91–98. doi:10.1007/s10163-013-0229-3

Mohammed-Nour, A., Al-Sewailem, M., & El-Naggar, A. H. (2019). The influence of alkalization and temperature on Ammonia recovery from cow manure and the chemical properties of the effluents. *Sustainability (Switzerland)*, *11*(8). doi:10.3390/su11082441

Mor, S., Chhoden, K., & Ravindra, K. (2016). Application of agro-waste rice husk ash for the removal of phosphate from the wastewater. *Journal of Cleaner Production*, *129*, 673–680. doi:10.1016/j.jclepro.2016.03.088

Mrudula, S., & Murugammal, R. (2011). Production of cellulose by Aspergillus niger under submerged and solid state fermentation using coir waste as a substrate. *Brazilian Journal of Microbiology*, *42*(3), 1119–1127. doi:10.1590/S1517-838220110003000033

Ngo, H. T. T., & Cavagnaro, T. R. (2018). Interactive effects of compost and pre-planting soil moisture on plant biomass, nutrition and formation of mycorrhizas: A context dependent response. *Scientific Reports*, *8*(1), 1–9. https://doi.org/10.1038/s41598-017-18780-2

Nigussie, A., Kuyper, T. W., Bruun, S., & de Neergaard, A. (2016). Vermicomposting as a technology for reducing nitrogen losses and greenhouse gas emissions from small-scale composting. *Journal of Cleaner Production*, *139*(x), 429–439. doi:10.1016/j.jclepro.2016.08.058

Norfadilah, N., Raheem, A., Harun, R., & Ahmadun, F. (2016). Bio-hydrogen production from palm oil mill effluent (POME): A preliminary study. *International Journal of Hydrogen Energy*, *41*(28), 11960–11964. doi:10.1016/j.ijhydene.2016.04.096

Nutongkaew, T., Duangsuwan, W., Prasertsan, S., & Prasertsan, P. (2014). Effect of inoculum size on production of compost and enzymes from palm oil mill biogas sludge mixed with shredded palm empty fruit bunches and decanter cake. *Songklanakarin Journal of Science and Technology*, *36*(3), 275–281.

Ogbe, V. B., Jayeoba, O. J., & Amana, S. M. (2015). Effect of Rice Husk as an Amendment On The Physico-Chemical Properties of Sandy-Loam Soil In Lafia, Southern-Guinea Savannah, Nigeria. *Production, Agriculture and Technology*, *11*(1), 44–55.

Oliveira, M. M. De, Coldebella, A., & Filho, P. B. (2018). Aeration frequency on accelerated composting of animal carcasses. *Ciência e Agrotecnologia*, *42*(6), 653–665.

Ozores-hampton, M. (2017). Guidelines for Assessing Compost Quality for Safe and Effective Utilization in Vegetable Production. *HortTechnology*, *27*(2), 1–4. doi:10.21273/HORTTECH03349-16

Pandey, A. (2003). Solid-state fermentation. *Biochemical Engineering Journal*, *13*(2–3), 81–84. doi:10.1016/S1369-703X(02)00121-3

Pandey, P. K., Vaddella, V., Cao, W., Biswas, S., Chiu, C., & Hunter, S. (2016). In-vessel composting system for converting food and green wastes into pathogen free soil amendment for sustainable agriculture. *Journal of Cleaner Production*, *139*, 407–415. doi:10.1016/J.JCLEPRO.2016.08.034

Partanen, P., Hultman, J., Paulin, L., Auvinen, P., & Romantschuk, M. (2010). Bacterial diversity at different stages of the composting process. *BMC Microbiology*, *10*, 1–11.

Pergola, M., Persiani, A., Maria, A., Di, V., Pastore, V., Adamo, C. D., & Celano, G. (2017). Composting : The way for a sustainable agriculture. *Journal of Applied Soil Ecology*, (October). doi:10.1016/j.apsoil.2017.10.016

Pode, R. (2016). Potential applications of rice husk ash waste from rice husk biomass power plant. *Renewable and Sustainable Energy Reviews*, *53*, 1468–1485. doi:10.1016/j.rser.2015.09.051

Prasara-a, J., & Gheewala, S. H. (2016). Sustainable utilization of rice husk ash from power plants : A review. *Journal of Cleaner Production*, 1–9. doi:10.1016/j.jclepro.2016.11.042

Pudełko, K. (2014). Effect of forced ventilation during composting on Agaricus bisporus substrate selectivity. *International Biodeterioration and Biodegradation*, *93*, 153–161. doi:10.1016/j.ibiod.2014.03.021

Qasim, W., Lee, M. H., Lee, B. E., Okyere, F. G., Khan, F., Nafees, M., & Kim, H. T. (2018). Composting of chicken manure with a mixture of sawdust and wood shavings under forced aeration in a closed reactor system. *International Journal of Recycling of Organic Waste in Agriculture*, *7*(3), 261–267. doi:10.1007/s40093-018-0212-z

Qian, X., Sun, W., Gu, J., Wang, X. J., Zhang, Y. J., Duan, M. L., … Zhang, R. R. (2016). Reducing antibiotic resistance genes, integrons, and pathogens in dairy manure by continuous thermophilic composting. *Bioresource Technology*, *220*, 425–432. doi:10.1016/j.biortech.2016.08.101

Raabe, R. D. (2018). The Rapid Composting Method. Retrieved from http://vric.ucdavis.edu/pdf/compost_rapidcompost.pdf

Raeze, S., Sulaiman, A., Baharuddin, A. S., Mokhtar, M. N., & Busu, Z. (2017). Physico-chemical Properties of Residual Oil Extracted from Oil Palm Decanter Cake. *Pertanika Journal of Science & Technology*, *25*, 157–168.

Rajor, A., Xaxa, M., Mehta, R., & Kunal. (2015). Use of Rice Husk Ash as Fertilizer Amendment to Soil and its Effect on Crop Germination. *National Conference on Emerging Trends In Chemistry-Biology Interface*, (January 2011), 1–2.

Ramli, N. H., Badrul Hisham, N. E., Mohd Said, F., & Mariyappan, T. (2016). The Effect of Weight Ratio on The Physiochemical Properties of Compost From Palm Oil Mill Effluent (POME) Sludge and Decanter Cake. *Australian Journal of Basic and Applied Sciences*, *10*(17), 34–39.

Rashad, F. M., Saleh, W. D., & Moselhy, M. A. (2010). Bioconversion of rice straw and certain agro-industrial wastes to amendments for organic farming systems: 1. Composting, quality, stability and maturity indices. *Bioresource Technology*, *101*(15), 5952–5960. doi:10.1016/J.BIORTECH.2010.02.103

Rattanachu, P., Toolkasikorn, P., Tangchirapat, W., Chindaprasirt, P., & Jaturapitakkul, C. (2020). Performance of Recycled Aggregate Concrete with Rice Husk Ash as Cement Binder. *Cement and Concrete Composites*, (103533). doi:10.1016/j.cemconcomp.2020.103533

Razaq, M., Zhang, P., Shen, H., & Salahuddin. (2017). Influence of nitrogen and phosphorous on the growth and root morphology of Acer mono. *Plos One*, *12*(2), 1–13. doi:10.1371/journal.pone.0171321

Reza, M., Moghadam, K., & Heidarzadeh, H. (2014). Response of silicate fertilizer effects , rice husk and rice husk ash on rice paddy growth an seed yield (Shiroodi cultivar) in pot condition. *International Journal of Farming and Allied Sciences*, *3*(4), 449–452.

Rihani, M., Malamis, D., Bihaoui, B., Etahiri, S., Loizidou, M., & Assobhei, O. (2010). In-vessel treatment of urban primary sludge by aerobic composting. *Bioresource Technology*, *101*(15), 5988–5995. doi:10.1016/j.biortech.2010.03.007

Rogoff, M. J. (2014). Processing Technologies. *Solid Waste Recycling and Processing*, 43–111. doi:10.1016/B978-1-4557-3192-3.00004-X

Rupani, P., & Singh, R. (2010). Review of current palm oil mill effluent (POME) treatment methods: Vermicomposting as a sustainable practice. *World Applied Sciences*, *11*(1), 70–81.

Sahad, N., Som, A. M., Baharuddin, A. S., Mokhtar, N., Busu, Z., & Sulaiman, A. (2014). Physicochemical characterization of oil palm decanter cake (OPDC) for residual oil recovery. *BioResources*, *9*(4), 6361–6372. doi:10.15376/biores.9.4.6361-6372

Sahebi, M., Hanafi, M. M., Siti, A., Akmar, N., Rafii, M. Y., Azizi, P., … Shabanimofrad, M. (2015). Importance of Silicon and Mechanisms of Biosilica Formation in Plants. *Hindawi Publishing Corporation*, *15*, 1–16. doi:10.1155/2015/396010

Sánchez, Ó. J., Ospina, D. A., & Montoya, S. (2017). Compost supplementation with nutrients and microorganisms in composting process. *Journal of Waste Management*, *69*, 136–153. doi:10.1016/j.wasman.2017.08.012

Saranya, P., Sri Gayathiri, C. M., & Sellamuthu, K. M. (2018). Potential Use of Rice Husk Ash for Enhancing Growth of Maize (Zea mays). *International Journal of Current Microbiology and Applied Sciences*, *7*(03), 899–906. doi:10.20546/ijcmas.2018.703.105

Sarkar, S., Pal, S., & Chanda, S. (2016). Optimization of a Vegetable Waste Composting Process with a Significant Thermophilic Phase. *Procedia Environmental Sciences*, *35*, 435–440. doi:10.1016/j.proenv.2016.07.026

Schaller, J., Cramer, A., Carminati, A., & Zarebanadkouki, M. (2020). Biogenic amorphous silica as main driver for plant available water in soils. *Scientific Reports*, *10*(1), 1–7. doi:10.1038/s41598-020-59437-x

Singh, G., Shamsuddin, M. R., & Lim, S. W. (2018). Characterization of Chicken Manure from Manjung Region Characterization of Chicken Manure from Manjung Region. *IOP Conference Series: Materials Science and Engineering*, *458*(012084), 1–6. doi:10.1088/1757-899X/458/1/012084

Singh, M. K., & Singh, P. (2014). *Handbook on vermicomposting : requirements, methods, advantages and applications*. Hamburg: Anchor Academic Publishing. Retrieved from https://books.google.com.my/books?id=JkFDCwAAQBAJ&dq=duration+for+vermicomposting&source=gbs_navlinks_s

Sinyoung, S., Kunchariyakun, K., Asavapisit, S., & MacKenzie, K. J. D. (2017). Synthesis of belite cement from nano-silica extracted from two rice husk ashes. *Journal of Environmental Management*, *190*, 53–60. doi:10.1016/j.jenvman.2016.12.016

Soccol, C. R., Costa, E. S. F. da, Letti, L. A. J., Karp, S. G., Woiciechowski, A. L., & Vandenberghe, L. P. de S. (2017). Recent developments and innovations in solid state fermentation. *Biotechnology Research and Innovation*. doi:10.1016/j.biori.2017.01.002

Song, X., Zhou, G., Ma, B. L., Wu, W., Ahmad, I., Zhu, G., … Jiao, X. (2019). Nitrogen application improved photosynthetic productivity, chlorophyll fluorescence, yield and yield components of two oat genotypes under saline conditions. *Agronomy*, *9*(3). doi:10.3390/agronomy9030115

Sullivan, D. M., Bary, A. I., Miller, R. O., & Brewer, L. J. (2018, October). Interpreting Compost Analyses. *OSU Extension Catalog*, (October), 1–10. Retrieved from https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/em9217.pdf

Sun, X., Lu, P., Jiang, T., Schuchardt, F., & Li, G. (2014). Influence of bulking agents on CH_4, N_2O , and NH_3 emissions during rapid composting of pig manure from the Chinese Ganqinfen system. *Journal of Zhejiang University-Science B (Biomedicine & Biotechnology)*, *15*(4), 353–364. doi:10.1631/jzus.B13a0271

Sundberg, C., Yu, D., Franke-Whittle, I., Kauppi, S., Smårs, S., Insam, H., … Jönsson, H. (2013). Effects of pH and microbial composition on odour in food waste composting. *Waste Management*, *33*(1), 204–211. doi:10.1016/j.wasman.2012.09.017

Syaima, M. T. S., Ong, K. H., Mohd Noor, I., Zamratul, M. I. M., Brahim, S. A., & Hafizul, M. M. (2015). The synthesis of bio-lubricant based oil by hydrolysis and non-catalytic of palm oil mill effluent (POME) using lipase. *Renewable and Sustainable Energy Reviews*, *44*, 669–675. doi:10.1016/j.rser.2015.01.005

Taeporamaysamai, O., & Ratanatamskul, C. (2016). Co-composting of various organic substrates from municipal solid waste using an on-site prototype vermicomposting reactor. *International Biodeterioration and Biodegradation*, *113*, 357–366. doi:10.1016/j.ibiod.2016.05.009

Trisakti, B., Mhardela, P., Husaini, T., Ghazali, N. F., & Mahmood, N. A. B. N. (2017). Effect of Turning Frequency on Composting of Empty Fruit Bunches Mixed with Activated Liquid Organic Fertilizer. *IOP Conference Series: Materials Science and Engineering*, *180*, 1–8. doi:10.1088/1742-6596/755/1/011001

Udoh, A., Abiola, T., & Eniola, G. (2013). Production , utilization and acceptability of organic fertilizers using palms and shea tree as sources of biomass. *African Journal of Agriculture Research*, *8*(27), 3483–3494. doi:10.5897/AJAR11.073

Vitcosque, G. L., Fonseca, R. F., Rodr, U. F., Neto, V. B., Couri, S., & Farinas, C. S. (2012). Production of Biomass-Degrading Multienzyme Complexes under Solid-State Fermentation of Soybean Meal Using a Bioreactor. *Enzyme Research 2012*, 1-9. doi:10.1155/2012/248983

Wahi, R., Chuah, L., Nourouzi, M., Ngaini, Z., Choong, T., & Yaw, S. (2017). Utilization of esterified sago bark fibre waste for removal of oil from palm oil mill effluent. *Journal of Environmental Chemical Engineering*, *5*(1), 170–177. doi:10.1016/j.jece.2016.11.038

Wang, J., Liu, Z., Wang, Y., Cheng, W., & Mou, H. (2014). Production of a water-soluble fertilizer containing amino acids by solid-state fermentation of soybean meal and evaluation of its efficacy on the rapeseed growth. *Journal of Biotechnology*, *187*, 34–42. doi:10.1016/j.jbiotec.2014.07.015

Williams, A., Hunter, M. C., Kammerer, M., Kane, D. A., Jordan, N. R., Mortensen, D. A., … Davis, A. S. (2016). Soil water holding capacity mitigates downside risk and volatility in US rainfed maize: Time to invest in soil organic matter? *PLoS ONE*, *11*(8), 1–11. doi:10.1371/journal.pone.0160974

Won, S., You, B., Shim, S., Ahmed, N., Choi, Y., & Ra, C. (2018). Nutrient variations from swine manure to agricultural land. *Asian-Australasian Journal of Animal Sciences*, *31*(5), 763–772.

Wun, W. L., Chua, G. K., & Chin, S. Y. (2017). Effect of Palm Oil Mill Effluent (POME) Treatment By Activated. *Journal CleanWAS*, *1*(2), 6–9.

Yahya, A., Sye, C. P., Ishola, T. A., & Suryanto, H. (2010). Effect of adding palm oil mill decanter cake slurry with regular turning operation on the composting process and quality of compost from oil palm empty fruit bunches. *Bioresource Technology*, *101*(22), 8736–8741. doi:10.1016/j.biortech.2010.05.073

Yan, Z., Song, Z., Li, D., Yuan, Y., Liu, X., & Zheng, T. (2015). The effects of initial substrate concentration, C/N ratio, and temperature on solid-state anaerobic digestion from composting rice straw. *Bioresource Technology*, *177*, 266–273. doi:10.1016/j.biortech.2014.11.089

Yaser, A. Z. (2019). *Green Engineering for Campus Sustainability*. (Abu Zahrem Yaser, Ed.). Singapore: Springer Nature Singapore Pte Ltd. doi:10.1007/978-981-13-7260-5

Yazid, N. A., Barrena, R., Komilis, D., & Sánchez, A. (2017). Solid-state fermentation as a novel paradigm for organic waste valorization: A review. *Sustainability (Switzerland)*, *9*(2), 1–28. doi:10.3390/su9020224

Yuan, J., Chadwick, D., Zhang, D., Li, G., Chen, S., Luo, W., … Peng, S. (2016). Effects of aeration rate on maturity and gaseous emissions during sewage sludge composting. *Waste Management*, *56*, 403–410. doi:10.1016/j.wasman.2016.07.017

Zainal, B. S., Danaee, M., Mohd, N. S., & Ibrahim, S. (2020). Effects of temperature and dark fermentation effluent on biomethane production in a two-stage up-flow anaerobic sludge fixed-film (UASFF) bioreactor. *Fuel*, *263*(November). doi:10.1016/j.fuel.2019.116729

Zainal, B. S., Ibrahim, M. H., A. Aziz, A., & Zainal, N. H. (2013). Studies on Vermicompost Production of Palm Oil Mill Effluent Sludge Using Eudrillus eugeniae. *Online International Interdisciplinary Reasearch Journal*, *3*(4), 42–50.

Zakarya, I. A., Khalib, S. N. B., & Mohd Ramzi, N. (2018). Effect of pH, temperature and moisture content during composting of rice straw burning at different temperature with food waste and effective microorganisms. *E3S Web of Conferences*, *34*(January), 1–8. doi:10.1051/e3sconf/20183402019

Zakarya, I. A., Noor, S., Khalib, B., & Ramzi, N. M. (2018). Effect of pH , temperature and moisture content during composting of rice straw burning at different temperature with food waste and effective microorganisms. In *International Conference on Civil & Environmental Engineering (CENVIRON 2017)* (Vol. 34, pp. 4–11).

Zhang, J., Ying, Y., & Yao, X. (2019). Effects of turning frequency on the nutrients of Camellia oleifera shell co-compost with goat dung and evaluation of co-compost maturity. *PLoS ONE*, *14*(9), 1–16.

Zhang, Y., Zhao, J., Jiang, Z., Shan, D., & Lu, Y. (2014). Biosorption of Fe (II) and Mn (II) Ions from Aqueous Solution by Rice Husk Ash. *BioMed Research International*, *2014*, 1–10. doi:10.1155/2014/973095

Zhou, J. (2017). Effect of turning frequency on co-composting pig manure and fungus residue. *Journal of the Air & Waste Management Association*, *67*(3), 313–321. doi:10.1080/10962247.2016.1232666

Zhou, J. M. (2017). The Effect of Different C/N Ratios on the Composting of Pig Manure and Edible Fungus Residue with Rice Bran. *Compost Science and Utilization*, *25*(2), 120–129. doi:10.1080/1065657X.2016.1233081

Zhou, S., Zhang, X., Liao, X., Wu, Y., Mi, J., & Wang, Y. (2019). Molecules Effect of Different Proportions of Three Microbial Agents on Ammonia Mitigation during the. *Molecules*, *24*, 1–18.